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The Impact of Ocean New Primary Productivity on High-Quality Development of Ocean Economy and Its Coupling Research

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Abstract: The New Quality Productivity is the evolution direction of advanced productivity, which ensures the high-quality growth of marine economy in China. The marine economy is the key to constructing a strong marine nation. This paper empirically uses the spatial autocorrelation analysis and coupled coordination degree model to examine the spatial and temporal evolution characteristics of new quality productivity on the high-quality development of marine economy using 11 coastal cities and provinces' panel data from 2011 to 2020. It also investigates the correlation between marine new-quality productivity and high-quality marine economic development. The study found that: (1) marine new quality productivity has a positive-going promotion influence on the superior growth of the maritime industry; (2) marine new quality productivity's development level, marine economy's high-quality advancement level, and the degree of coordination coupling's degree of development of China's coastline comprises eleven provinces and cities show an overall upward trend. Yet, there are variations in the development of each province and city, the cities and provinces in the east and south being superior to the northern part of the country; (3)A feature of spatial clustering exists in the degree to which coastal cities and provinces' high-quality development is coordinated with the marine economy and new quality productivity. In addition, this study broadens the scope of new quality productivity and provides corresponding countermeasure suggestions for the excellent growth in the marine economy.

Keywords: New Quality Productivity of Marine; High Quality of the Marine Economy; Degree of Coupling Coordination; Science and technology Innovation; Spatial and Temporal Evolution Features

1. Introductory

In February 2024, State leaders pointed out that "it is necessary to seize major opportunities to boost the new productivity's cultivation and formation in the marine field and to shape new advantages and kinetic energy for high-quality development of the oceans". Subsequently, he emphasized that to "strive for strength in the sea and dream of the deep blue", to expedite the construction of new productivity in the oceans is essential. From a big maritime nation to a powerful maritime nation, national leaders have repeatedly emphasized that "high-quality development's strategic place is the ocean", pointing out that "new productivity's development is an intrinsic necessity and an important focus point for promoting high-quality development". It is evident that the marine new quality productivity, which is the new form of productivity that depends on the development and use of marine resources and is focused on scientific and technological advancement, is turning into a crucial element supporting the marine economy's superior growth.

The new quality productivity, as the advanced productivity of the new era brought about by subversive technological advances, creative production factor distribution, and rapid industry upgrading, has become the advanced productivity that promotes high-quality development of the economy. A modern nation must be built with high-quality development as its main goal. Therefore, a thorough comprehension of the meaning of new quality productivity levels and the rate at building new quality productivity quickly will help speed up the pace of Chinese-style modernization. Lately, China's marine economy has made great progress, but at the same time, it is also facing problems such as low quality of development, unreasonable structure, and escalating ecological environment pressure. An in-depth investigation

of the impact on marine new levels of productivity of quality on the superior growth of the marine economy is of great theoretical and practical value in promoting China's maritime sector to realize a greater quality, more equitable, effective, and sustainable growth.

The new quality of productivity to enable superior advancement of the maritime sector has turned into a key direction of research within the marine economy. Through combing through the literature, it is found that there is a relatively mature systematic theory throughout the new quality productivity system promoting high-quality development of the marine economy. New quality productivity promotes the marine economy's high-quality development through technological advancements, optimization of industrial structure, and improvement of resource allocation efficiency.[1] At the same time, studies on the combination of NQP and the marine economy's excellent development tend towards "macro-ize" the economic concept of NQP.[2,3] However, they have failed to quantify the indicators from the marine industry's level in connection to the new quality productivity's deep meaning. Although some scholars have constructed the evaluation index system of marine productivity of new quality at the level of new worker types, novel kinds of work items and new type of labor materials, and measured the data [4], but they have inevitably fallen into the research path of unidimensional framework.

In view of this, the paper's cumulative contributions mainly include: (1) Empirically analyzing the influence effect of the former on the latter in the dualistic research structure of marine new levels of productivity quality and marine economic development of superior quality. And classifying the degree of match between marine new quality productivity and marine economic excellent development in accordance with the coupling degree of coordination model, thus laying empirical evidence for the subsequent adjustment of the strategy to achieve the optimal match between the two. The Moran index is used to analyze whether there is a spatial influence on the degree of synergistic development of the two systems of marine new-quality productivity and superior growth in the marine economy, and to visualize the spatio-temporal evolution characteristics. Based on the historical data, this paper applied the grey prediction model (GM(1,1)) to predict the degree of coupled and synchronized creation of 11 coastal provinces and cities of the new level of productivity quality and superior growth in the marine economy in the period of 2021-2026.

2. Hypotheses and Theoretical Analysis

High-quality economic development is a high-level state of economic development mode transformation, structure and power[5] , is the outcome of economic structure optimization, the conversion of old and new kinetic energy, synergistic economic and social development, and a notable rise in living standards once the economic scale has reached a particular level of growth.[6] The marine economy's excellent growth generally takes the five development concepts as the starting point, and builds a comprehensive evaluation index system for the marine economy's excellent growth from the five dimensions of "innovation, coordination, greenness, openness and sharing".[7]

Innovation in science and technology is essential to new quality productivity. [8] In the dimension of "innovation", the first factor promoting the superior growth of the marine economy is innovation, and marine industry's competitiveness is continuously improved through the research and development of new technologies, new products and new forms of business. In the "green" dimension, national leaders have pointed out that "green development is the background color of high-quality development, and the new quality productivity itself is green productivity." Low-carbon and sustainability is new quality productivity's inherent requirement, and the new quality productivity releases good ecological efficiency.[9] In the dimension of "openness" and "sharing", the idea of open development is upheld by the new quality productivity, it can utilize both domestic and foreign markets, and the incentive of greater market demand can increase organizations' readiness to increase production scale, and promote the product innovation and service innovation of related industries. And the notion of shared development is upheld by the new productivity quality, which is in line with the development requirements of society.[10] As a result, the following hypotheses are proposed:

H1: New Quality Productivity in the Ocean Positively Enabling High-Quality Development of the Ocean Economy

3. Research Design

3.1 Comprehensive Evaluation

3.1.1 Construction of the indicator system

The new quality productivity makes the leap between laborers, labor supplies, labor items, and their ideal pairing as the elementary meaning. Regarding the construction of the indicator system of marine new productive forces, the essay utilizes the methodology of Ye and Wang et al. (2024)[4], and builds the marine new quality productivity evaluation indicator system in three dimensions: new type of laborers, new type of labor objects, and new type of labor materials. As shown in Table 1.

According to the current requirements and work deployment for promoting high-quality economic development in China, the promotion of superior marine economic development in coastal cities and provinces focuses on realizing the goals of high efficiency, innovation, coordination, sustainability, opening and sharing. Therefore, this paper evaluates the degree to which China's coastal cities and provinces have developed their marine economies in five different ways, namely innovation, coordination, greening, openness and sharing. Based on the principles of data availability and scientific evaluation, five indicators are selected for each of the five levels to build a system of indicators for the superior growth of the marine economy in 11 provinces and cities in China. As shown in Table 2.

Table 1. Indicator System for Evaluating Marine Neoplasmatic Productivity

Primary indicators	Secondary indicators	Measurement	Indicator attribute
New type of laborers	Worker skills	Percentage of marine scientific research institutions with senior titles	+
		The composition of students attending universities in the maritime field	+
	Labor productivity	Marine capital stock per capita	+
		Gross Maritime Product (GMP) per person employed in sea-related employment	+
New Worker Objects	New industry	Share of marine tertiary sector in GDP	+
		Marine-related industries' value added/ Marine and associated industries' value added	+
		Marine research, education, and management services' added value / Marine industry value added	+
	Ecological environment	Total industrial wastewater discharges/Gross coastal area product	-
		Spending on environmental conservation / Government spending on public finances	+
New means of labor	Material and means of production	Revenue from information technology services in the coastal region as a share of GDP	+
		Long-distance fiber-optic cable length per unit area in the coastal region	+
	Intangible means of production	Patents per capita for marine technological and scientific endeavors	+
		Share of oceanic R&D expenditure/ ratio of gross domestic product (GDP)	+
		Level of digitization of enterprises in the coastal region	+

Table 2. An indicator System for Assessing the Marine Economy's Degree of Superior Development

Primary Indicators	Secondary indicators	Indicator attribute
Innovation	Marine R&D investment intensity	+
	Intensity of investment in marine scientific research papers	+
	Number of marine scientific research projects	+
	Percentage of marine researchers with master's degrees	+
	Marine productivity per unit of coastline	+
Coordination	Gross Maritime Product (GMP)	+
	Share of marine tertiary industry	+
	Investment in fixed assets	+
	Coefficient of difference in disposable income between urban and rural residents in coastal areas	-

	Employment deviation in the marine industry	-
Greening	Number of marine nature reserves	+
	All-encompassing use of general industrial solid waste	+
	Urban sewage treatment rate	+
	Area of offshore and coastal wetlands	+
	Wastewater discharge per unit of GDP	+
Openness	International standard container throughput at coastal ports	+
	External trade dependence	+
	Amount of foreign direct investment actually utilized	+
	Value added of major marine industries	+
	Number of travel agencies	+
Sharing	Disposable income of coastal town residents	+
	Green space per capita in parks	+
	Number of beds in health facilities	+
	Number of sea-related employment	+
	Fishermen's net income per capita	+

3.1.2 Calculation of the composite score

In this study, the weights of each indicator of the degree of marine new quality productivity and high-quality development of the marine economy in 11 Chinese coastal provinces and cities are determined using the entropy weight method from 2011 to 2020. Firstly, so as to make the data comparable, each indicator's data is standardized by dimensionless processing; secondly, the weight, difference coefficient and information entropy of each indicator are calculated for each year; finally, the scores of each coastal province and city on the level of marine new quality productivity and high-quality development of the marine economy in the corresponding years are calculated according to the weights of each indicator.

3.2 Effects of Marine New Quality Productivity

3.2.1 Variable selection

To better assess how marine new quality productivity affects on the high-quality development of marine economy, this paper chooses the following proxy variables.

(1) Explained and explanatory variables

On the basis of the above constructed index-based evaluation system on marine new quality productivity's degree and marine economic high-quality development, the entropy value approach is employed to find out the explanatory variable of this paper, the marine economic high-quality development's level. Furthermore, this paper's main explanatory variable, the degree of development of marine new quality productivity, is computed.

(2) Control variables

There are many factors affecting the degree of excellence in the marine economy's development, and based on the results of previous research, population growth (POP), transportation infrastructure (TI), government fiscal expenditure (GOV), level of economic development (PGDP), and environmental regulation intensity (ER) are selected as variables under control. Between them, the natural population growth rate serves as a representation of POP, TL is proxied by the sum of highway density and railroad density, the ratio of local fiscal spending to GDP is used to calculate GOV, PGDP is represented by the per capita GDP of the region, and the ratio of the finished industrial pollution control investment to the industry's value added is how ER is calculated.

3.2.2 Modeling

For the effect of marine new quality productivity on the high-quality development of the marine economy, this study uses a model with two-way fixed-effects to estimate benchmark regressions, which is set up as equation (1):

$$MHQD_{it} = \alpha_0 + \alpha_1 MNQP_{it} + \alpha_2 Z_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

Where t and i stand for year and province, respectively. $MHQD_{it}$ represents the degree of superior growth of the maritime economy in year t of province (city) i, and $MNQP_{it}$ represents the development level of marine new quality productivity in year t of province (city) i, and Z_{it} represents control variables, and μ_i denotes individual fixed effects, and δ_t represents time fixed effects, and ε_{it} is the randomized disturbance term.

3.2.3 Data description

Table 3 shows the descriptive statistics of the

variables, considering the data availability, this study uses panel data from 2011 to 2020 from 11 Chinese coastal cities and provinces, and logarithms some of the data in order to eliminate the possible heteroskedasticity problem. China Marine Economic Statistics Yearbook, China Marine Statistics Yearbook, China Statistical Yearbook, and China Environmental Statistics Yearbook are the primary sources of the data.

Table 3. Variable Descriptive Statistics

Variable type	Variable name	Name (of a thing)	Observed value	Average value	standard deviation	minimum value	maximum values
Explanatory variable	Degree of the marine economy's superior development	MHQD	110	0.29	0.13	0.07	0.60
Core explanatory variables	Marine NQP	MNQP	110	0.21	0.13	0.04	0.59
Control variable	population growth rate	POP	110	0.05	0.03	-0.02	0.11
	Transportation infrastructure	TI	110	1.20	0.44	0.45	2.17
	Government expenditure	GOV	110	0.12	0.04	0.07	0.25
	Level of economic development	PGDP	110	9.63	0.41	8.90	10.58
	Intensity of environmental regulation	ER	110	0.00	0.00	0.00	0.01

3.3 Coupled harmonization Model

With the development of globalization and ocean economy, all countries are actively laying out the ocean strategy, in order to assess whether the ocean's new quality productivity matches with the ocean economy's excellent growth, so as to adjust the strategy for the follow-up in order to achieve the optimal cooperation between the two, this paper analyzes this dynamic relationship by adopting the model of coupling coordination degree. According to the existing research, the degree model of coupling coordination mainly examines the coupling degree, the coordinating index, the degree of relative development and the degree of coupling coordination. According to the coupling coordination development degree and relative development degree, This work makes reference to Xie and Wang et al.'s methodology [11], and determines the degree of coordination development and coordination level classification criteria (Table 4), and evaluates how well subsystems are coupled and coordinated.

The degree of coupling coordination is computed as equation (2) to (4):

$$C=2\times\left[\frac{f(x)\times g(x)}{(f(x)+g(x))^2}\right]^{\frac{1}{2}} \quad (2)$$

$$T=\alpha f(x)+\beta g(x) \quad (3)$$

$$D=\sqrt{C\times T} \quad (4)$$

Where C is the coupling degree; T is the comprehensive coordination index; D is the coupling coordination degree; f(x) and g(x) denote the marine new quality productivity and marine economic high-quality development scores, respectively; the coefficients β and α need to be found, and it is generally assumed that the two subsystems are equally important, so β =α = 0.5.

Table 4. Criteria for Classifying the Level of Harmonization and the Degree of Development of Harmonization

Degree of coupling coordination	Relative degree of development	developmental stage	Coupled and coordinated development characteristics
(0, 0.5)	(0, 0.8)	lack proper care	1. New marine productivity is being developed at a slow and dislocated pace.
	[0.8, 1.2]		2. Synchronized development with low levels of dissonance
	> 1.2		3. Marine neoplasmatic productivity is overdeveloped and highly dislocated
[0.5, 0.7)	(0,0.8)	wear in	4. Lagging development of marine NQP and low abrasion

	[0.8,1.2]		5. Synchronized development and high degree of integration
	> 1.2		6. Overdevelopment of marine NPS and low abrasion
[0.7, 1.0]	(0,0.8)	trade-off	7. Lagging development of marine new quality productivity and low level of coordination
	[0.8,1.2]		8. Synchronized development with a high degree of coordination
	> 1.2		9. Over-development and under-coordination of marine NPS

3.4 Moran Index

This paper applies global correlation analysis and local correlation analysis to investigate whether there is a spatial effect on the synergistic development of China's eleven coastal provinces and cities have two systems of marine new quality productivity and high quality marine economy development and analyze their spatial clustering characteristics by figuring out the local and global Moran's I. The spatial autocorrelation is visualized by drawing Lisa diagrams using ArcGIS 10.8. Refer to the literature for the calculation method of the two types of Moran index. Meanwhile, this paper adopts economic geography nested matrix to carry out spatial autocorrelation analysis.

3.5 Gray Prediction Model GM (1,1)

GM(1,1) model is a mathematical model in gray system theory, which is mainly used to deal with systems with uncertainty and incomplete information. By analyzing the historical data, the GM(1,1) model can reveal the intrinsic laws of the data and make more accurate predictions of future trends accordingly. Therefore, the study uses the GM(1,1) gray prediction model to forecast the coupled and coordinated development degree of high-quality marine economic development and new marine productivity in 11 Chinese coastal provinces and cities between 2021 and 2026.

4. Results and Analysis

4.1 Analysis of the NQP of the oceans and the HQD of the marine economy

The composite scores of the eleven municipalities and provinces along the coast in relation to the degree of excellence in the marine economy's development during the period 2011-2022 generally show a solid upward trend (Figure 1), but regional differences are obvious. In terms of the absolute amount of the composite score, Guangdong and Fujian provinces maintain high degrees of the oceanic economy's development, with their composite scores exceeding 0.3; Guangxi and Hainan and the northern provinces and municipalities have lower composite scores, with all of them except Shandong province below 0.3 during the study period. From a relative perspective, the increase in the southern provinces and cities is particularly significant, with Guangdong and Fujian increasing their composite scores by nearly 0.2 over the study period, while the overall increase in the northern and eastern regions is not significant. In terms of geographic coordination, the eastern provinces have a better-coordinated degree of superior marine economy development, while the southern provinces and municipalities have a greater difference in their level of development.

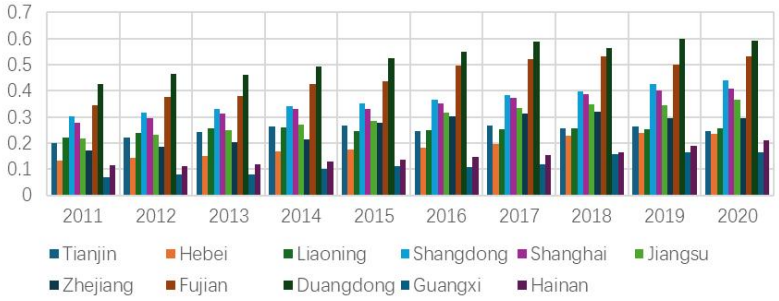


Figure 1. Comprehensive Score of the Degree of Excellent Marine Economy Development in 11 Coastal Cities and Provinces in China, 2011-2020

The 11 coastal provinces and municipalities generally showed an increasing trend in the level

of development of new marine productivity during the 2011-2020 period (Figure 2), but regional heterogeneity was evident. From the perspective of composite score values, eastern and southern provinces and cities generally scored higher, especially Guangdong and Shanghai with score values as high as 0.6 when the study period is over; while the northern region scored lower, with only Tianjin exceeding 0.3 when the study period is over. From the perspective of increase, the level of development of the new quality productivity in the eastern provinces and the southern provinces grew faster, while that in the northern provinces was relatively low. From the perspective of coordinated development, the extent to which the eastern provinces have developed new quality productivity is more coordinated, with little difference in development levels, while the degree to which the south has developed new quality productivity is more varied, with lower developmental stages in Guangxi and Hainan, and higher levels of development in Guangdong and Fujian.

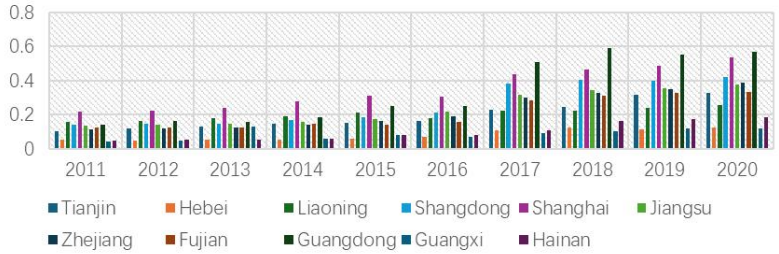


Figure 2. Comprehensive Scores of the Development Level Of Marine New Quality Productivity in 11 Chinese Coastal Provinces and Cities, 2011-2020

4.2 Analysis of the relationship between the marine economy's HQD and marine NQP

4.2.1 Benchmark regression

To ensure that the model's output is reliable, both the two-way fixed effects model and the least squares model are applied in regression analysis, and Table 5 presents the findings, where columns (1) through (2) display the least squares model's regression results, and columns (3) through (4) display the two-way fixed effects model's regression results. It can be seen that marine new levels of productivity quality in both models demonstrates a favorable effect on the improvement of the level of high-quality development of the marine economy and passes the significance level test, suggesting that the level of high-quality development of the marine economy can be considerably raised by marine new quality productivity and reflecting the reliance on scientific and technological innovation. It is also benefit from the use of innovative technology, and improves the the marine economy's productivity and resource utilization, thus promoting the maritime economy. The H1 hypothesis is preliminarily verified.

Table 5. Benchmark Regression Results

variant	(1)	(2)	(3)	(4)
	OLS	OLS	FE	FE
mnqp	0.716***	0.569***	0.187***	0.095**
	(10.82)	(7.42)	(4.54)	(2.19)
pop		1.019***		0.063
		(3.61)		(0.26)
ti		-0.028		-0.043
		(-0.98)		(-0.99)
gov		-0.994***		0.404***
		(-4.04)		(2.72)
pgdp		0.158***		0.104***
		(4.64)		(3.59)
er		-3.185		-0.191
		(-0.79)		(-0.15)
constant term (math.)	0.142***	-1.235***	0.203***	-0.795***
	(8.81)	(-4.13)	(25.98)	(-2.88)
area fixed effect	NO	NO	YES	YES

Year fixed effects	NO	NO	YES	YES
N	110	110	110	110
R^2	0.5158	0.6460	0.8227	0.8717

Note: ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively, with t-values in parentheses.

4.2.2 Endogeneity and robustness tests

Since there may be a mutual causal relationship between marine new quality productivity and excellent growth in the maritime economy, which leads to endogeneity problems in the model. This paper adopts the pre-determined core explanatory variables and one-period lagged and two-period lagged explanatory variables as instrumental variables, and utilizes the difference GMM method to conduct the endogeneity test, and at the same time, autoregression (AR) is used to detect the correlation of the perturbation series, and the Sargan test is used to to determine the validity of instrumental variables. As shown in model (5) of Table 4, the model's perturbation terms do not exhibit second-order or higher-order serial autocorrelation, as indicated by the P-values of AR (1) and (2) being less than 0.05 and greater than 0.1, respectively.; and Sargan's test P-value is higher than 0.1, meaning the model passes the over-identification test.

Robustness test this paper mainly takes: to avoid the extreme outliers of the data biased conclusions of the study, the sample data are re-estimated after two-sided 1% shrinkage treatment of the model; through re-testing the regression analysis by substituting the core explanatory variables and explanatory variables into the model using principal component analysis; taking into account that the economic development level and policy support situation of the central government of Shanghai and Tianjin has direct control over the two municipalities are different from other provinces, which may affect the promotion of marine new quality productivity to the superior growth of the maritime industry, the two municipalities will be excluded from the study sample and re-examined. The results of the robustness test are shown in Table 6, Model (6)~Model (8), the significance of the core explanatory variables and the sign of the variables are basically consistent with the regression results of the baseline model, which shows that the robustness is good.

Table 6. Endogeneity and Robustness Tests

variant	endogeneity test	robustness analysis		
	(5)	(6)	(7)	(8)
	DIFF-GMM method	shrinkage treatment	Replacement calculation method	Excluding municipalities
l.mhqd	0.464** (2.08)	0.583*** (8.57)	0.329*** (3.07)	0.469*** (3.85)
mnqp	0.087* (1.67)	0.065*** (2.75)	0.210* (1.69)	0.098** (2.07)
pop	0.203 (1.27)	0.167 (1.19)	8.706*** (5.71)	0.331 (1.38)
ti	0.248 (1.50)	0.178* (1.95)	-0.378 (-0.76)	0.239* (1.91)
pgdp	0.000 (0.00)	-0.014 (-0.32)	0.343 (0.46)	-0.084 (-1.30)
er	1.819* (1.71)	1.564 (1.33)	1.914 (0.07)	2.277* (1.90)
AR(1)	0.094	0.053	0.038	0.093
AR(2)	0.260	0.322	0.835	0.224
Sargan	0.116	0.269	0.159	0.266
N	110	110	110	90

Note: with z-values in parenthesis, the symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

4.3 Coupling Coordination Analysis

The coupling coordination degree of 11 coastal provinces and cities (Table 7) is analyzed to

explore the provincial aggregation dynamics of coupling synergistic development. It can be seen that the coupling coordination degree of China's coastal provinces and cities generally shows a better trend. Guangdong will turn into a highly coordinated state of synchronized development by 2020, and Fujian will be in a low degree of friction state of overdevelopment of marine new quality productivity, indicating that the southern part of the country has a high degree of coupling coordination; Tianjin, Shanghai, and Zhejiang will turn into a low degree of friction type of lagging development of marine new quality productivity after nearly a decade of strategic development of the oceans; and Liaoning, Shandong, and Jiangsu provinces will finally turn into a high degree of synchronized development, indicating that there is a synergistic development of both the northern and eastern parts of the country. The three provinces of Liaoning, Shandong and Jiangsu are finally in a synchronized development and highly integrated state, indicating that there are "highlands" of coordinated development in both the north and the east; Hebei and Guangxi are always in a state of overdevelopment and high dissonance of the new marine productivity; and Hainan is finally in a state of synchronized development and low dissonance. According to the analysis above, the two systems' levels of coordinated development exhibit some degree of regional heterogeneity, with significant spatial imbalances between the internal provinces.

Table 7. Coupling Coordination Analysis

Coupled and coordinated development characteristics	*2011*	*2014*	*2017*	*2020*
Synchronized development, low level of dissonance				Hainan
Marine neoplasmatic productivity is overdeveloped and highly dislocated	11 coastal provinces and municipalities	Tianjin, Hebei, Liaoning, Shandong, Jiangsu, Zhejiang, Fujian, Guangxi, Hainan	Tianjin, Hebei, Liaoning, Guangxi, Hainan	Hebei, Guangxi
Lagging development of marine neoplasmatic productivity, low abrasion				Tianjin, Shanghai, Zhejiang
Synchronized development and high degree of integration		Shanghai	Shandong, Shanghai, Jiangsu, Zhejiang	Liaoning, Shandong, Jiangsu
Oceanic neoplasmatic productivity overdevelopment and low abrasion		Guangdong	Fujian	Fujian
Synchronized development with a high degree of coordination			Guangdong	Guangdong

4.4 Spatial autocorrelation analysis

4.4.1 Global spatial autocorrelation analysis

Examine if the degree of marine high-quality development and the growth of marine new quality productivity are correlated spatially. From Table 8, from 2010 to 2020, the global Moran index of the degree of coupling and coordination of marine new quality productivity and marine economic high-quality development is almost always positive, and only in 2013 is negative, which shows that, except for 2013, the data of the other nine years show spatial positive correlation, the similarity value tends to spatially agglomerate during the study time. Therefore, in 11 coastal provinces and cities, the coupling coordination between the level of marine high-quality development and the development of marine new quality productivity exhibits a spatial clustering characteristic, meaning that those that are dysfunctional are next to those that are dysfunctional, and those that are coordinated are next to those that are coordinated.

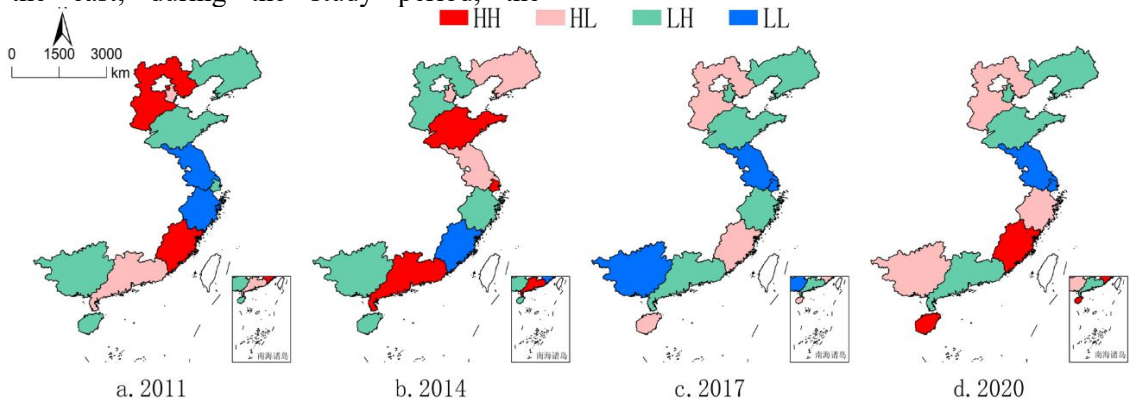
Table 8. Global Moran Index of Coupled Harmonization of Marine NPS and Excellent Growth in the Maritime Economy, 2010-2020

particular year	*D*	*particular year*	*D*
2011	0.101***	2016	0.120***
2012	0.095**	2017	0.099***
2013	-0.010	2018	0.076**
2014	0.100***	2019	0.111***
2015	0.045*	2020	0.115***

4.4.2 Local spatial autocorrelation analysis

Plotting the local spatial autocorrelation Lisa maps of the coupled coordination levels of the

two systems in 11 provinces and cities in 2011, 2014, 2017, and 2020 provides information about the temporal and spatial distribution of spatial correlation patterns (Figure 3), to further explore the aggregation of local spatial correlation and the distribution characteristics. There is a spatial non-equilibrium in the spatial distribution of the spatial correlation patterns of the coupled coordination levels of the 11 Chinese provinces and cities along the coasts from 2011 to 2020. The HH aggregation type is found in the north, east and south, and decreases and then increases over time, showing a trend of "shrinking to the south", which shows that the sea's high quality development level and marine new quality productivity are comparatively well-coupled and coordinated in the eastern and southern coastal regions, and it is important to promote the surrounding area systems's coordination and stability in the strategic and comprehensive development of the oceans. The majority of the LL agglomeration type is found in the east; during the study period, the distribution is comparatively stable, and the number progressively exhibits a declining trend, these areas form a low coupling and coordination correlation area, and the positive effect of the correlation is larger, so it is necessary to follow the requirements of the strategic layout of the development of the new era of the ocean, relying on its own advantages in development, and due to the increased productivity of high quality, to break through the existing limitations of the low-coordination radiation. The distribution of LH agglomeration types is relatively stable, mainly in the northern and southern regions, while HL agglomeration types show a changing trend, with the number of provinces increasing. It is clear that mutual promotion has a coordinated development effect, and the decline in LL agglomeration areas suggests that the coupling and coordination level of the marine new quality productivity-ocean economy high-quality development system in the coastal areas has improved overall.



Note: HH is high-high agglomeration; HL is high-low agglomeration; LH is low-high agglomeration and LL is low-low agglomeration.

Review No.: GS (2022) 1873 Supervised by the Ministry of Natural Resources

Figure 3. Geographically Localized Correlation Between the Degree of Coordination and Coupling Between Marine New Quality Productivity and High-Quality Marine Economy Development in China's Coastal Provinces and Cities, 2011-2020

4.5 Prediction of coupling coordination

Between 2021 and 2026, the degree of coupled and coordinated development of new quality productivity and high-quality development of the marine economy was predicted in 11 coastal provinces and municipalities using the GM(1,1) gray prediction model (Figure 4). Although there were variations in the development of the coupled and coordinated degree of each province and municipality, the combined degree of the 11 provinces and municipalities exhibited an overall upward trend during the prediction period. The four cities and provinces of Guangdong, Shandong, Fujian, and Shanghai are consistently in a state of coordinated development (above 0.7), while two provinces, Jiangsu and Zhejiang, are projected to move from a grinding stage (above 0.5) to a state of coordinated development in 2023. Four provinces and cities except Guangxi are also predicted to reach the grinding stage in the later period as well, while Guangxi still cannot reach the grinding stage in the prediction period and has a slow upward trend in the coupling coordination degree, and needs to further

improve its coupling coordinated development level.

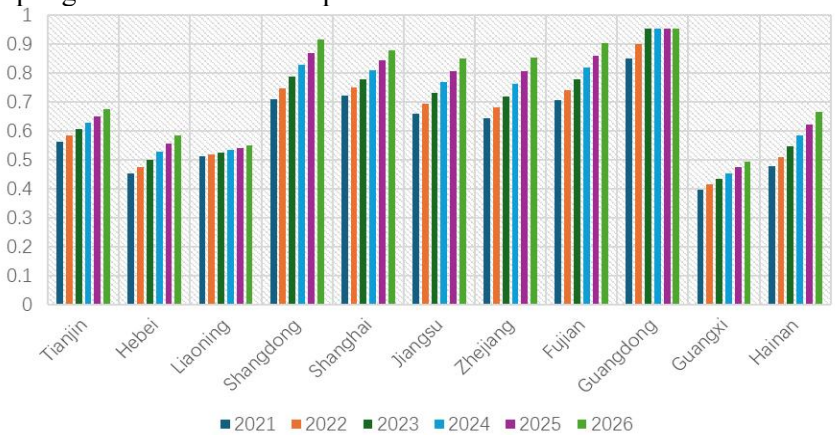


Figure 4. Projected Results of Coupled And Harmonized Development

5. Conclusions and recommendations

5.1 Conclusions

This study examines how the high-quality development of China's marine economy is affected by new quality productivity using panel data for 11 coastal cities and provinces between 2010 and 2020, and creates the system of evaluation indices for marine new quality productivity and the degree of high-quality development of the marine economy, concurrently uses the entropy weight approach to determine the marine new quality productivity scores and the degree of high-quality development scores of the marine economy for each coastal city and province in the relevant years. Then analyzes the evolution trend and distribution characteristics of the coupling coordination degree of the two, and made the following deductions after using the Lisa diagram to determine the spatial correlation pattern of the two synergistic developments and its spatiotemporal evolution law:

According to the regression model, the marine economy's high-quality development is positively impacted by marine new quality productivity; the measurement's findings indicates that China's coastal provinces and cities are experiencing an overall increase in marine new quality productivity and high-quality marine economy development, but there are differences in the level of development between provinces and cities. Guangdong Province and Fujian Province posse a greater degree of superior marine economy development, while Guangxi and Hainan Province are relatively low; The coupling coordination degree analysis reveals that, generally speaking, there is a tendency for the marine economy's high-quality development in towns and provinces along the coast to be coordinated with the new quality productivity of the ocean, however, there is a discrepancy in the degree of coordinated development between municipalities and provinces. Some provinces and municipalities, such as Guangdong, Fujian, Shandong and Shanghai, have reached a higher level of coordinated development, while other provinces and municipalities are in the teething stage or need to further improve the level of coupled coordinated development; the spatial autocorrelation analysis shows that the degree of coupled coordination between the oceans' new quality productivity in coastal provinces and municipalities and the quality development of the marine economy exhibits a spatial clustering characteristic, that is, the areas of high coupled coordination are in close proximity to the areas with a high coupled coordinativeness and low coupled coordination are in close proximity to each other; the Lisa diagram shows that the high coupling coordination (HH) agglomeration types are distributed in the north, east and south, and show a trend of "shrinking to the south", the LL agglomeration types are mainly distributed in the east, and the number is gradually decreasing. In both the north and the south, the LH agglomeration types are comparatively stable, and HL agglomeration types show a trend of increasing number in the province; According to the prediction results, the coastal provinces' and cities' overall coupling coordination degree will keep increasing over the coming years, and some provinces and cities will realize the transition from the stage of friction to the stage of coordinated development, however, Guangxi and other provinces and cities's coupling

coordination degree is in a slow increase, which need to be further strengthened to ensure that the new quality productivity of the oceans and the marine economy's excellent development are Combined promotion.

5.2 Recommendations

The findings mentioned above lead to the following suggestions:

Strengthening cooperation and exchanges in coastal regions to realize coordinated regional economic development. For Guangxi Hainan and the northern coastal provinces and cities, so as to improve the coupling and coordination of the high-quality development of the marine economy and the ocean's new quality productivity, the local government should promote the cooperation and exchange between local enterprises and regions with a high level of coordinated development status, and promote the flow of talents, materials and information. Firstly, it should improve the construction of marine-related infrastructure, such as marine transportation infrastructure, offshore platforms, etc., and at the same time, enhance the preservation and development of marine resources to support the long-term growth of the marine economy. Secondly, we should make full use of the radiation-driven role of Shanghai, Guangdong and Shandong Province, and reasonably utilize the resource advantages of areas with high-quality development of the marine economy to drive the economic development of the region, and at the same time establish some preferential incentives to promote the flow of resources to the region. Thirdly, it is necessary to promote the formation of industrial clusters, promote the synergistic development of the upstream and downstream of the marine industry chain, and form a marine economic pattern with complementary advantages and win-win cooperation.

Reasonable and full utilization of digital technology to narrow the information gap between regions. Regions relatively backward in how the marine economy is developing, such as the coastal regions in the north, Guangxi, Hainan and so on, increasing their investment in digital technology is necessary. Firstly, we should accelerate the construction of digital infrastructure such as 5G network, promote the all-round coverage of network services, promote the 5G network coverage of islands, fishing villages, wharves, etc., and make full use of the "5G sea" action plan of economically developed regions to create blue ocean business cards of innovation economy such as 5G+ sea ranch and 5G+ smart ship. Secondly, we should deeply research and develop blockchain technology. Information becomes very transparent under big data, and the use of blockchain technology can ensure the safety and sharing of information, such as blockchain technology can record the information of fishing vessels' fishing and sales to ensure the legitimacy of catches, and can also register the property rights of marine fisheries to protect the legitimate interests of fishermen.

Investment in new quality productivity should be continuously increased, especially in Hainan, Guangxi, and provinces and cities along the northern coast that have low coupling and coordination with the excellent growth in the marine economy. Firstly, enterprises had better continue to improve their independent innovation capacity, and master key technologies in their own hands; Secondly, We should boost talent vitality, improve multi-principal collaborative education, increase industry, university, and research institute collaboration, and develop more high-level composite talents that are suited to the growth of new, high-quality productive forces in a range of forms. Thirdly, we should fully explore the resource endowment and characteristic development potential of the region, formulate individualized development positioning and development strategy in line with the region, create a regional characteristic brand, and improve regional competitiveness, for the purpose of encouraging the growth of the marine economy.

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